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flamingos are distinctly anseriform in this particular. Finally it may be added that the study of the under tail-coverts has never been undertaken and will probably give results as interesting and suggestive as those afforded by the study of the major upper coverts.

FERRUGINOUS STAINS ON WATERFOWL.

BY FREDERIC H. KENNARD.

SEVERAL years ago at a meeting of the Nuttall Ornithological Club at which I was present, there was an informal discussion among some of the members, regarding the ferruginous suffusion that occurs so frequently on the heads of certain geese, especially the Snow Geese and Blue Geese.

Some of those present seemed inclined to the belief that it might be a phase of adult plumage, while others thought it merely a rusty stain, such as occurs sometimes on the under parts of many of our ducks.

One eminent ornithologist then pertinently inquired, why, if it were a stain, it should be so strictly confined, as a rule, to the forehead and cheeks, with swans as well as geese, and why also it should occur in certain species of waterfowl, but not in others having essentially the same habits and haunts. Another member wisely suggested that a chemical analysis should be made of some of the rusty feathers in question; but nothing further was done at that time.

Personally, I had, without giving much thought to the subject, always supposed this to be a stain caused by extraneous matter deposited in some way by the muddy water in which the birds fed.

During the winter of 1916, my interest in this subject was again awakened, while on a collecting trip after Blue Geese along the Louisiana marshes bordering the Gulf of Mexico, and I have been able, during the past year, to gather data from a number of museums and private collections, which included large series of skins

of the genus *Chen*, Blue Geese, Lesser and Greater Snow Geese, and Ross's Geese, as well as a series of Emperor Geese, all apt to be more or less stained about their heads; and a series of the Canada group of the genus *Branta*, including the Canada, Hutchins', and Cackling Geese, apparently having essentially the same habits and haunts, but which nevertheless remain practically unstained throughout the year.

In view of the fact that there still seems to be a good deal of uncertainty among some of our ornithologists regarding these ferruginous suffusions, the following notes, in which I have tried to answer the questions raised at the Nuttall Club meeting, may be of interest.

During the summer of 1917, Professor S. C. Prescott of the Massachusetts Institute of Technology very kindly offered to make a chemical analysis of such stained plumages as seemed necessary. He examined feathers from various parts of Blue Geese, Greater and Lesser Snow Geese, Mallards, Gadwalls, Blue-winged Teal, Green-winged Teal, Baldpates, Shovellers, Canvas-backs, Ring-necked Ducks, and Ruddy Ducks, and reported that "the results of these analyses in all cases showed that the coloration was due to iron, which was deposited in the form of ferric oxide (Fe_2O_3) on the tips of the feathers. The white feathers showed the coloration most pronouncedly, as was to be expected, but even the dark brown and black feathers of some species showed the presence of the iron. It is easy to show by micro-chemical methods that the oxide of iron is deposited on the outside of the feather, and does not penetrate into the tissue."

Professor Prescott also writes that "it seems to me quite likely that different kinds of feathers from the same bird will exhibit differences in the degree of coloration they are likely to undergo. The colored feathers have a different chemical structure, and will be less stained, just as colored cloths will dye less readily than white ones."

One of the birds that we examined, for instance, an adult male Ring-necked Duck, collected among the sloughs of the Mississippi Delta, had its white belly completely covered with stain, while its black breast appeared nearly as glossy as that of an unstained bird, and yet these same black feathers gave a positive reaction of oxide

of iron. An adult Mallard drake, collected on the Mississippi Delta, was badly stained all over its belly, and the dark feathers of its breast, on which the stain was hardly noticeable, gave a positive reaction. The white collar was badly discolored, while the iridescent green feathers of the neck immediately above the collar, apparently just as glossy and green as ever, also gave a positive reaction.

In the meantime Mr. H. S. Swarth, of the University of California, called my attention to a similar investigation away back in 1910 by Dr. Joseph Grinnell, which had previously escaped my notice,[1] in which he writes as follows regarding the Red-throated Loon,— "Common, and thought to be breeding about the head of Cordova Bay. Two adult specimens, taken there June 9 and 10, have the entire lower surface, where it is normally snowy white, of a bright ferruginous tinge. This color is intensest on the exposed portions of the feathers, suggesting adventitious origin. Dr. M. Vaygouny of the Department of Chemistry of the University of California, determined by analysis that the discoloration is due to the presence of ferric oxide (Fe_2O_3), probably deposited from the water of the marshes in the immediate locality. As the Red-throated Loon moults in the spring, the discoloration must have been acquired since April 1; and furthermore, the species probably does not arrive from the south until that date at earliest. Therefore, the deposit has been surprisingly rapid. The iron oxide in the water is said to result from bacterial action, and precipitation is liable to occur freely on organic substances of certain textures. Evidently the loon's feathers are especially favorable. The same deposit was noticed to a less extent on certain other birds of the same locality, as hereinafter noted."

Again in the same publication, Dr. Grinnell writes of three Northern Phalaropes, collected at the Head of Cordova Bay, June 11 to 14, which "have the lower surface of the body rusty-stained, as in the case of the loons from the same place before described."

The stain is very persistent, but invariably disappears with the moulting of the feathers, when the bird is in captivity, or when the

[1] Birds of the 1908 Alexander Alaska Expedition with a Note on the Avifaunal Relationships of the Prince William Sound District, by Joseph Grinnell, University of California Publications in Zoölogy, Vol. 5, No. 12, March 5, 1910.

bird has changed its feeding ground to a locality where there is no ferric oxide present.

The next question is,— why, when the stain does occur, should it be confined so generally to the heads of the birds under consideration. As a matter of fact, it is not so strictly thus confined as many people seem to suppose, but occurs frequently on their bellies and tibiæ, and less often on their breasts.

In the case of the Blue Geese, with whose feeding habits I am familiar, the stains on their heads seem undoubtedly due to their method of feeding about the shallow sloughs among the marshes and flats along the Louisiana coast. The crops of all those birds which I have examined, which contained anything at all, were full of the roots of certain tall, grass-like plants, which grew about the shallow sloughs and wet flats, but which I did not identify. What seems a simple explanation is, that the feeding bird, standing in the shallow water with his belly usually clear of the surface, sticks its head beneath the surface and digs with its bill in the mud among the roots of the grasses and decayed vegetation, riling the muddy water, and gradually by repeated application acquiring a deposit of oxide of iron upon its forehead and cheeks, and perhaps the rest of the head and neck. It is possible that the alternate wetting and drying may aid in the deposit. If the water be deep enough, so that the tibiæ, belly and breast become immersed, these parts of the plumage may also become discolored. The deposit seems to be rapidly acquired.

Mr. W. L. McAtee of the Biological Survey has written very fully of the habits of the Blue Goose in feeding on the roots of certain grasses.[1]

I am not personally familiar with the feeding habits of the other members of the genus *Chen*, except with those of the few Lesser Snow Geese that consort with the Blue Geese in southern Louisiana. Their feeding habits, so far as I have been able to observe, are exactly like those of the Blue Geese, digging just as they do for their food among the grass roots of the marshes and shallow sloughs. It seems reasonable to infer, however, that the other members of

[1] Notes on Chen cærulescens, Chen rossi, and other Waterfowl in Louisiana. 'The Auk,' July, 1910, pp. 337–339.

the *Chen* group, the Greater Snow Goose and Ross's Goose, and also the Emperor Goose, all of which are apt to become discolored about their heads, undoubtedly acquire the stain in the same way, viz, — by digging.

The last question,— why the rusty stains occur with certain species of waterfowl, but not with others having essentially the same habits and haunts,— is perhaps more difficult to answer definitely, owing to our lack of knowledge of the habits and haunts of some of them. The breeding ground of the Blue Goose is unknown, but was supposed by Professor Wells W. Cooke to be somewhere in the interior of Ungava in the northern part of the Labrador Peninsula,[1] and the bird has been reported from Baffin Land.[2] I find, on looking over a series of more than a hundred Blue Geese, that adults taken early in their autumn migration, are usually unstained or very slightly so, while the juvenal and immature birds are free from discoloration. On the other hand, all the Blue Geese, taken during the winter, along the Louisiana marshes, are more or less stained. Those taken nearest the Mississippi Delta seem to be most discolored; and those taken in Cameron Parish less so; while birds collected in Galveston Bay, Texas, are apt to be comparatively free from stain. Of the young birds that arrive in Cameron Parish early in October, those which were hatched late and are still in juvenal plumage are unstained. As soon, however, as they begin to moult and to show white feathers about their heads and necks, these feathers begin to acquire the rusty stain, while similar birds taken in Galveston Bay remain comparatively unstained.

Wherever the breeding range of the Blue Goose may be, it appears that those birds which have acquired the stain while wintering in the South, lose it during their summer moult, and as a rule start south unstained. Those birds that fly south along the Mississippi River may acquire the stain anew, while feeding among the bordering bayous and sloughs, while those that fly farther west, and come down into Texas, may remain unstained.

Of the Lesser Snow Geese examined, about fifty per cent were

[1] Distribution and Migration of North American Geese, Ducks and Swans, U. S. Dept. of Agriculture, Biological Survey, Bulletin 26.

[2] Bernard Hantzschs Ornithologische Ausbeute in Baffinland by Dr. Erich Hesse, in 'Journal für Ornithologie,' April, 1915.

unstained. Adults, when they reach their winter range, may or may not be discolored, while the young of the species usually arrive unstained. Louisiana birds become more stained during the winter, while Texas birds remain comparatively unstained. In California, where the Lesser Snow Goose and Ross's Goose winter in large numbers, together with various kinds of Canada Geese, in the San Joaquin and Sacramento Valleys, the percentage of stained birds is comparatively small. Mr. Swarth writes: "I note on our California collected birds that this stain is most apparent on specimens collected through the fall. In such birds as undergo more or less of a moult during the winter or early spring, it seems to disappear by April. The inference is, that it is acquired in their northern home." I have never visited these valleys, but am told that the birds feed among grain fields, pastures, and adjacent swamps, instead of muddy sloughs, as in the Louisiana marshes. The conclusion is obvious, that these birds lose their stain because of the absence in this locality of muddy, iron-bearing waters such as are found in the Louisiana marshes.

We are told by Prof. Cooke, that the breeding range of the Lesser Snow Goose reaches from the mouth of the Mackenzie River east to Coronation Gulf and the Melville Peninsula; and the bird has since been taken on Banks Island.[1] In all this expanse of country, conditions must vary greatly, and it seems reasonable to suppose that those geese that moult and summer among fresh water ponds remain unstained, while those birds that live about the deltas, or muddy flats along the iron-bearing rivers may, after they moult, acquire the stain which they bring south with them. To put it more concisely, it appears that the Lesser Snow Goose may or may not acquire the stain upon its northern range. Those birds that do acquire it, lose it if they start moulting upon their winter range in California, while those birds that winter along the marshes bordering the Gulf of Mexico are apt to become more stained the nearer they are to the mouth of the Mississippi River.

Very little is known of the breeding range and habits of the Greater Snow Goose. Prof. Cooke seemed to think it probable that they "breed for the most part in Victoria Land," though

[1] Summary Report of the Geological Survey, Department of Mines, Canada, 1916.

I have found no record from there. They have, however, been taken in Labrador and a breeding female and downy young were secured in north Greenland. Wherever their summer range may be, the only unstained specimens examined were young birds taken early in October; while over ninety-five per cent of them, both immature and adult, come south discolored about their heads; and a majority of them also about their tibiæ, bellies, and breasts, with a stain that must have been acquired after their summer moult, either upon their breeding grounds or somewhere in their northern range. As they come south later than the Lesser Snow Goose, usually not arriving on the Atlantic Coast before the latter part of December, they have apparently had more time to acquire the stain, which is usually much heavier than in the case of the Lesser Snow Goose, which arrives south in October. Prof. Cooke writes that "there is no sharply defined line in the Mississippi Valley between the winter ranges of the greater and the lesser forms. In general the greater snow goose is more common east of the Mississipi River, and winters from southern Illinois to the Gulf."

The Greater Snow Goose doubtless occurs as a straggler along the Mississippi Valley, just as we occasionally get a Blue Goose or a Lesser Snow Goose on the Atlantic Coast; I have seen a number of specimens erroneously tagged *Chen hyperboreus nivalis;* but out of the large series of skins examined I have seen only two from the Central States really referable to that subspecies, and these had wandered clear out to Dakota.

These birds seem to winter along the Atlantic Coast from New Jersey to North Carolina, feeding there along the sandy beaches, or adjacent flats thrown up by the action of the sea, and presumably free from iron deposit.

The breeding range of the Ross's Goose is, like that of the Greater Snow Goose, still unknown; but wherever it may be in the far north, while this bird is not so frequently discolored as its larger cousins, the Greater Snow Geese, a small proportion of them do acquire the stain sometime after the summer moult, which they bring to California, and like their cousins, the Lesser Snow Geese, lose it there, when they start moulting.

The breeding range of the Emperor Goose extends along the west coast of Alaska from the Kotzebue Sound south to the Kuskoquim

River, principally about the delta of the Yukon River. The birds are also found in East Siberia, and are said to winter among the Aleutian Islands. Owing to the comparative rarity of this species, I have been able to examine but thirty-three specimens. Of these, seven were unstained; one taken on Bristol Bay, Alaska, on May 16, and the other six September birds, either juvenal, or adults that had but recently finished their moult. The remaining birds were all stained, those from East Siberia slightly so, while those from Alaska were very badly discolored.

I have been unable to obtain any data as to their stomach contents; but Mr. F. Seymour Hersey tells me that they are marsh feeders, reminding him in their habits of the Blue Goose, with the feeding habits of which he is also familiar. These birds apparently acquire this stain along the marshes of the west coast of Alaska, and about the Yukon Delta, and presumably their feeding habits must be similar to those of the genus *Chen.*

Let us now turn to the Genus *Branta,* which seems to remain unstained throughout the year. We know more about the range, both winter and summer, of the Canada Goose, a stained specimen of which is very exceptional, and we might logically argue that its unstained condition throughout the year is owing to the fact that, while its breeding range is enormous, it really is a bird of the interior, breeding usually about the clean fresh-water ponds and lakes rather than among the deltas and flats of the sea-coast; and wintering generally either in the country west of the Mississippi, or on the Atlantic Coast, and away from the muddy iron-bearing waters of the Mississippi Delta.

In what way, however, are we to account for the fact that the Hutchins' Goose, which winters in California, together with the Lesser Snow Goose, and which breeds in the Kowak Valley in Alaska, and from the mouth of the Mackenzie east along the Arctic shore to the Melville Peninsula, remains unstained, and in practically the same range, as that in which the Lesser Snow Goose often becomes discolored? In this case, the haunts are approximately the same.

The Cackling Goose breeds along the west coast of Alaska from Kotzebue Sound south across the Yukon Delta to the Alaska Peninsula throughout approximately the same range as the Emperor

Goose, and remains as a rule unstained. I have examined a few Cackling Geese with cheeks slightly stained, but discolored specimens of this species, as well as of the Hutchins' and Canada Geese, are so uncommon as to be negligible.

I have not attempted to gather any data regarding the other members of the *Branta* group. The White-cheeked Goose, a bird of the Pacific slope, has presumably habits similar to its cousin, the Canada Goose, and but seldom acquires the stain, while the Brant are salt-water birds.

The dark feathers of the heads and necks of this group of birds naturally do not show the stain as do those with the white heads; but their cheeks should show it, if present, and their lower parts as well. Such stains are, however, very exceptional, and the deduction seems reasonable, that their feeding habits cannot be the same. According to a letter from Mr. McAtee, "the stomach contents bear out this idea. *Branta* contains more largely things which may be cropped and few root stocks; while *Chen* has more largely the latter. On the whole also, *Branta* spends more time in the water than *Chen* and feeds more on water plants, while *Chen* feeds more on land, where not only digging, but often hard digging is required to get the things it wants."

As a summary of the above notes, and in answer to the questions asked at the Nuttall Club meeting, it seems to be proven:

First: That the ferruginous suffusion is caused in every case by an extraneous deposit of oxide of iron (Fe_2O_3) on the outside of the tips of the feathers;

Second: The stain upon the heads of certain of our geese seems undoubtedly to be brought about by their habit of digging for their food among the mud and decayed vegetation in the iron-bearing waters of the marshes and shallow sloughs, among which they feed at certain seasons, particularly in places adjacent to the deltas of the great muddy rivers;

Third: Those species of the *Branta* group which remain unstained, and inhabit essentially the same haunts as those of the *Chen* group or the Emperor Geese, which become stained, do not have the same feeding habits. They are apt either to frequent deeper waters where they feed upon the grasses and aquatic plants, or else they are found upon the drier fields and prairies in preference to shallow

muddy sloughs; and they are as a rule croppers rather than diggers.

In general, it appears that swans, geese, and ducks, or other waterfowl, may become stained if their feeding habits bring them among iron-bearing waters; particularly about the deltas of such great muddy rivers as the Mississippi, the Mackenzie or the Yukon.

Swans frequently acquire the stain about their heads somewhere on their summer range, but those that winter in the east appear to lose it during their sojourn on the Atlantic Coast, while those wintering on the Gulf are apt to retain it.

Those ducks that winter along the Atlantic Coast remain, as a rule, unstained while those wintering along the Louisiana Coast, particularly about the Mississippi Delta, are apt to become badly stained.

While these notes have been limited to the few species actually examined chemically, there are many others that appeared to be similarly stained, both from this country and abroad.

In assembling the data, upon which these notes are necessarily based, I am indebted, not only to the ornithologists already mentioned, but to several others who have very kindly supplied me with data from collections to which they had access. My thanks are particularly due to Messrs. Bangs, Bent, Bishop, Brewster, Dwight, Fleming, Oberholser, Osgood, Stone, and Taverner, members of the A. O. U.; and to Messrs. E. A. McIlhenny of Avery Island, Louisiana, and John Heywood of Gardner, Mass., game conservationists.